

TECHNICAL LIBRARY

AD

TECHNICAL MEMORANDUM ARLCB-MR 80015

COMPARISON OF MECHANICAL PROPERTIES OF 105MM M68 GUN TUBE FORGINGS

H. J. Powis

May 1980



US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
LARGE CALIBER WEAPON SYSTEMS LABORATORY
BENET WEAPONS LABORATORY
WATERVLIET, N. Y. 12189

AMCMS No. 32970675888

PRON No. 1A7270501A1A

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

DISCLAIMER

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

The use of trade name(s) and/or manufacturer(s) does not constitute an official indorsement or approval.

DISPOSITION

Destroy this report when it is no longer needed. Do not return it to the originator.

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-MR-80015	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Comparison of Mechanical Properties of 105MM M68 Gun Tube Forgings		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) H. J. Powis		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, N.Y. 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 32970675888 PRON No. 1A7270501A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon System Laboratory Dover, New Jersey 07801		12. REPORT DATE May 1980
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		13. NUMBER OF PAGES 22
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Cannon Tubes ESR Rotary Forging Gun Steel		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) 105mm M68 gun tube forgings are supplied at present by two vendors and the Watervliet Arsenal rotary system. A study was initiated to compare mechanical properties of the most recent vendor-supplied tubes with those supplied by them in the past. The vendor-supplied tubes were produced from vacuum degassed steel, whereas the rotary forged tubes were produced from electroslag remelted (ESR) steel. The study shows that the quality of tubes, in terms of mechanical properties varies between vendors, but that the quality from each vendor has remained fairly constant. The study also shows that the tubes produced from ESR are equivalent to those produced by conventional forging and heat treating techniques.		

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

TABLE OF CONTENTS

	Page
ABSTRACT	1
INTRODUCTION	2
RESULTS AND DISCUSSION	3
CONCLUSIONS	4

TABLES

CHART I	Comparison of Processes	5
CHART II	Comparison of Mechanical Properties	6
GRAPH I	Yield Strength - Vendor "A" Tubes (1970-1973)	7
GRAPH II	Reduction in Area - Vendor "A" Tubes (1970-1973)	8
GRAPH III	Charpy Impact - Vendor "A" Tubes (1970-1973)	9
GRAPH IV	Yield Strength of Vendor "B" Tubes (1970-1973)	10
GRAPH V	Reduction in Area - Vendor "B" Tubes (1970-1973)	11
GRAPH VI	Charpy Impact - Vendor "B" Tubes (1970-1973)	12
GRAPH VII	Yield Strength - Vendor "A" Tubes (1977)	13
GRAPH VIII	Reduction in Area - Vendor "A" Tubes (1977)	14
GRAPH IX	Charpy Impact - Vendor "A" Tubes (1977)	15
CHART X	Yield Strength - Vendor "B" Tubes (1977)	16
CHART XI	Reduction in Area - Vendor "B" Tubes (1977)	17
CHART XII	Charpy Impact - Vendor "B" Tubes (1977)	18
CHART XIII	Yield Strength Rotary Forged Tubes (1977)	19
CHART XIV	Reduction in Area Rotary Forged Tubes (1977)	20
CHART XV	Charpy Impact Rotary Forged Tubes (1977)	21

COMPARISON OF MECHANICAL PROPERTIES
OF 105MM M68 GUN TUBE FORGINGS

ABSTRACT

105mm M68 gun tube forgings are supplied at present by two vendors and the Watervliet Arsenal rotary forge system. A study was initiated to compare mechanical properties of the most recent vendor-supplied tubes with those supplied by them in the past. The vendor-supplied tubes were produced from vacuum degassed steel, whereas the rotary forged tubes were produced from electroslog remelted (ESR) steel. The study shows that the quality of tubes, in terms of mechanical properties varies between vendors, but that the quality from each vendor has remained fairly constant. The study also shows that the tubes produced from ESR are equivalent to those produced by conventional forging and heat treating techniques.

Key Words

Cannon Tubes
ESR
Rotary Forging
Gun Steel

INTRODUCTION

Watervliet Arsenal is supplied with 105mm M68 gun tube forgings by two private industry vendors and by the rotary forge integrated line system. This study was initiated to compare the mechanical properties obtained by each method of production.

The two vendors use open die forged solid vacuum degassed ingots for their gun tube forgings, and trepan and rough machine prior to heat treatment. The rotary forging procedure in use when these data were generated was to first rotary forge a solid ingot to the preform outside diameter and then cut it to length to produce two preforms. The solids were trepanned and then hot rotary forged over a mandrel to the finished forging dimensions. The vendors also use annealing, normalizing, and rough machining operations prior to the hardening and tempering heat treatment of the tubes. In the rotary forge integrated line system, these steps are eliminated. Only a sawing operation is required to trim the tubes to heat treat length.

A comparison of the methods of production is shown in Chart I, giving typical procedures and times involved in each. It should be noted that the rotary forging system is a much faster method of producing gun tube forgings.

APPROACH

A random sampling of tubes from each source was used in the study. Since the first production of tubes by the rotary forge system was in 1977, the sampling from the vendors was taken from forgings supplied by them in the same year. A sampling of forgings was also taken from those supplied by them from 1970 to 1973.

The data used in the study were obtained from the certified vendors tests and from tests taken at Watervliet of the rotary forge forgings. These tests are in accordance with MIL-S-46119, ASTM-A370-65 and applicable Watervliet Arsenal drawings. The data involved are for yield strength, percent reduction in area, and impact energy.

RESULTS AND DISCUSSION

The data are shown by histograms in Graphs I-XV. A statistical analysis of the mechanical property data was made by computer. The results are summarized in Chart II. The means of the yield strength, reduction in area and Charpy impact, satisfied the specifications of 160,000 to 180,000 psi yield strength, 25% minimum reduction in area, and 15 ft/lb. minimum Charpy impact at -40°F. The forgings produced by the rotary forge system were equal to those of

vendor B and were, like vendor B's, better than those of vendor A. The reduction in area and impact strength of vendor B and the rotary forged forgings were higher than vendor A.

CONCLUSIONS

1. Both the rotary forge method and conventional forging supply high quality gun tube forgings.

2. The vendors, over the years, have consistently supplied a quality product.

3. The method of heat treatment, vertical or horizontal, is capable of producing the same mechanical properties.

CHART I

<u>Vendor</u>	<u>Material</u>	<u>Forge Pre-Heat</u>	<u>Forging</u>	<u>Component</u>	<u>Preparation for Heat Treat</u>	<u>Heat Treatment</u>	<u>Completion of Product</u>
A	Vacuum Degassed Ingot	Horizontal Furnace	Open Die	Solid Gun Tube Forging	Sub-Critical Anneal Rough Machine and Trepan	Vertical Furnaces Normalize Harden Temper	Finish Machine
B	Vacuum Degassed Ingot	Horizontal Furnace	Open Die	Solid Gun Tube Forging	Anneal Rough Machine and Trepan	Vertical Furnaces Normalize Harden Temper	Finish Machine
Rotary Forge Integrated Line	ESR Ingot*	Induction Heater	Rotary Forge	Hollow Gun Tube Forging	Cut to Heat Treat Length	Horizontal Continuous Barrel Line Furnace Harden and Temper	Finish Machine

*Rotary forged to a solid preform, trepanned into a hollow preform, and rotary forged into a tube.

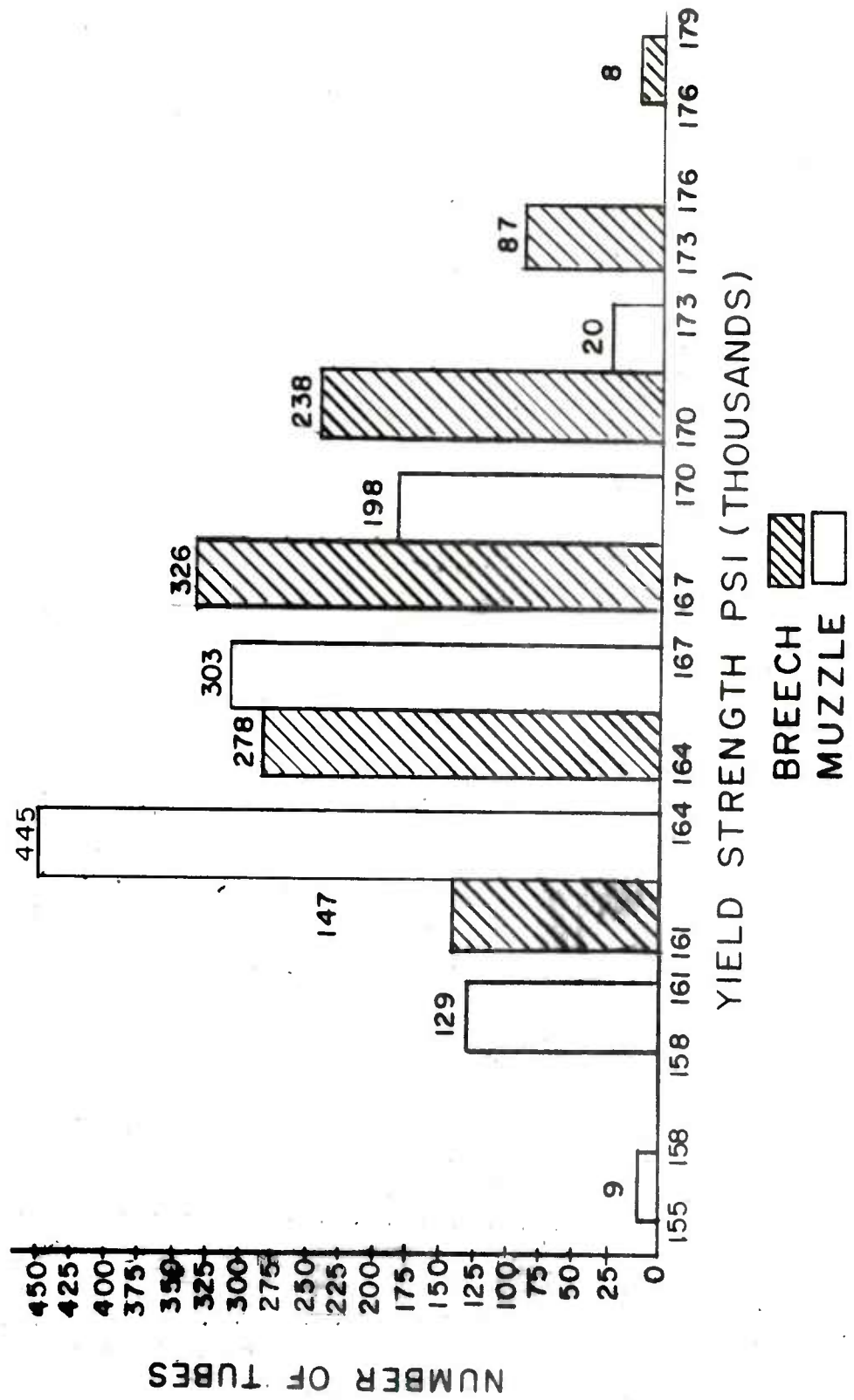
CHART II

	VENDOR A		VENDOR B		ROTARY FORGE
	1970-1973	1977	1970-1973	1977	1977
Yield Strength					
Breech End(Range)	160.0/185.5	164.5/178.0	160.5/179.0	162.0/173.0	162.6/179.5
Average	168.4	171.5	169.3	167.7	170.5
Muzzle End(Range)	157.0/182.7	163.5/174.0	160.2/176.5	161.0/174.5	156.6/172.2
Average	168.4	169.6	168.5	167.1	164.6

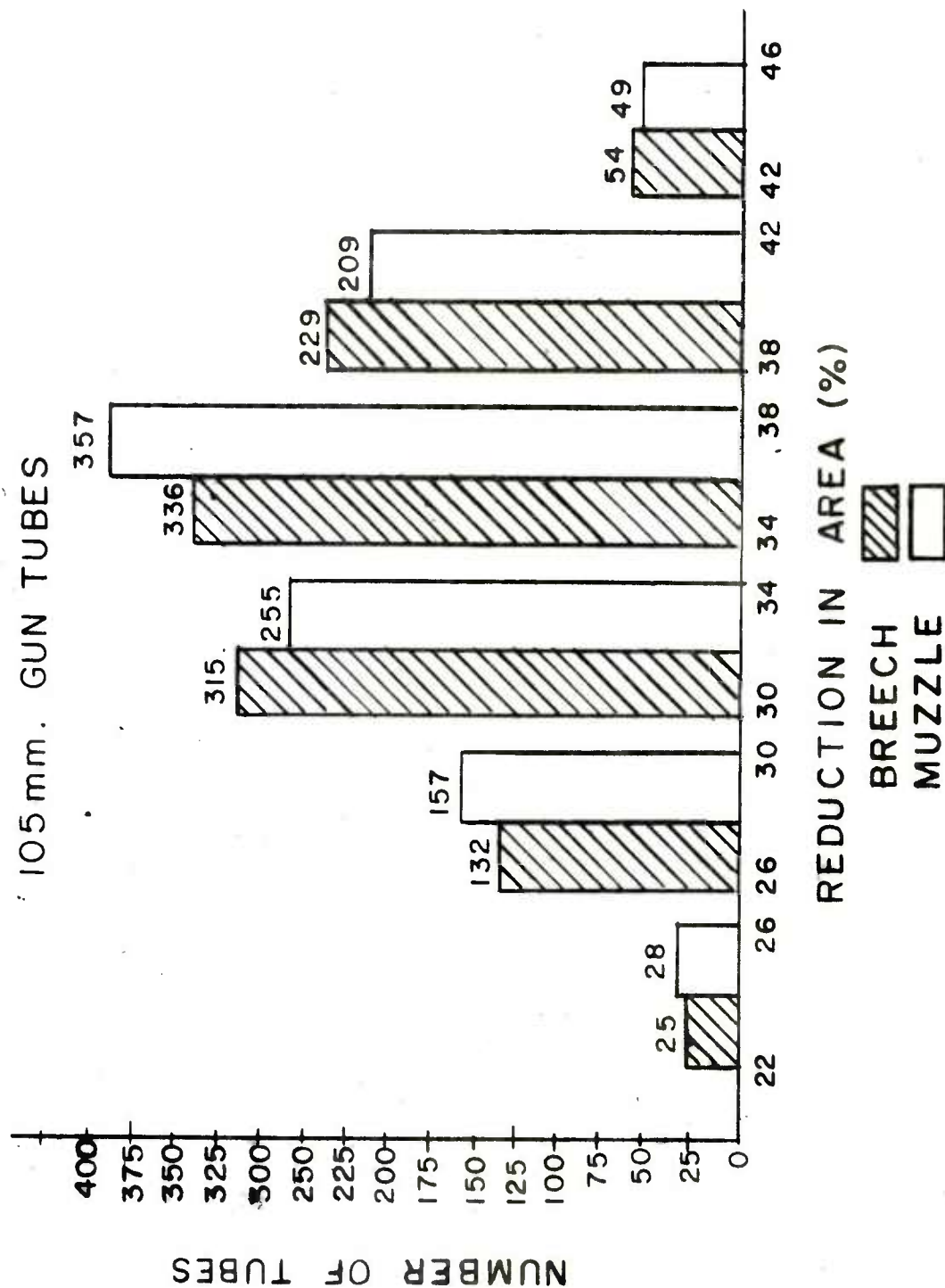
	VENDOR A		VENDOR B		ROTARY FORGE
	1970-1973	1977	1970-1973	1977	1977
RA %					
Breech End(Range)	25/46	28/44	32.2/55.6	32/54	35/52
Average	34.8	34.7	45.5	46.2	44.7
Muzzle End(Range)	25/46.9	25/42	36.3/55.9	37/55	32/58
Average	34.8	34.3	47.5	46.8	45.8

	VENDOR A		VENDOR B		ROTARY FORGE
	1970-1973	1977	1970-1973	1977	1977
Cv-40°					
Breech End(Range)	12.5/25.5	15/23	16.5/37.5	18/34	18/34
Average	17.7	18.7	27	27.5	25.2
Muzzle End	11/24	15/23	17.5/40	18/38	19/35
Average	17.2	18	28.1	27.4	27

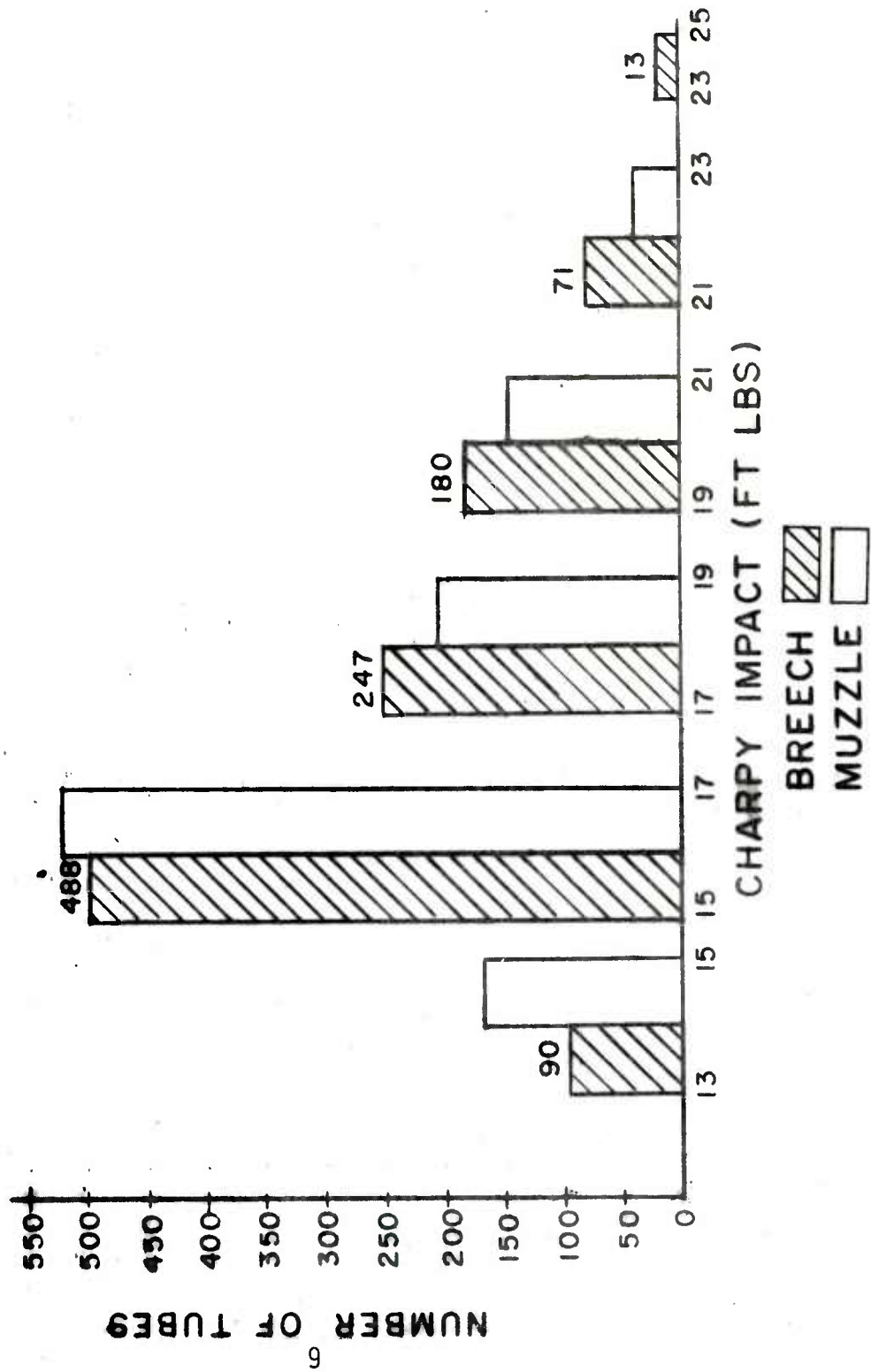
GRAPH I MECHANICAL PROPERTIES VENDOR A (1970-1973) 105mm. GUN TUBES



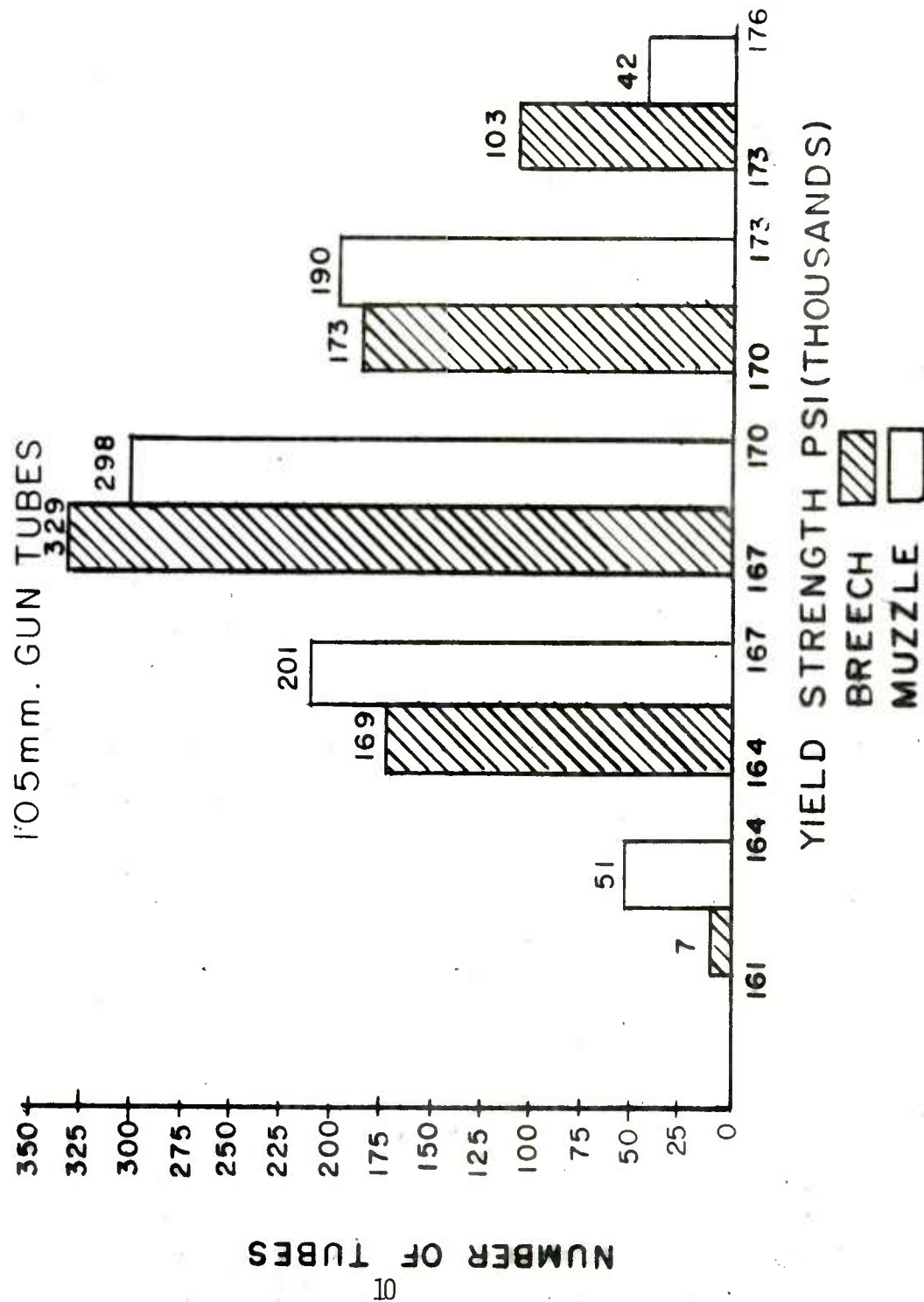
GRAPH II MECHANICAL PROPERTIES VENDOR A (1970-1973) 105mm. GUN TUBES



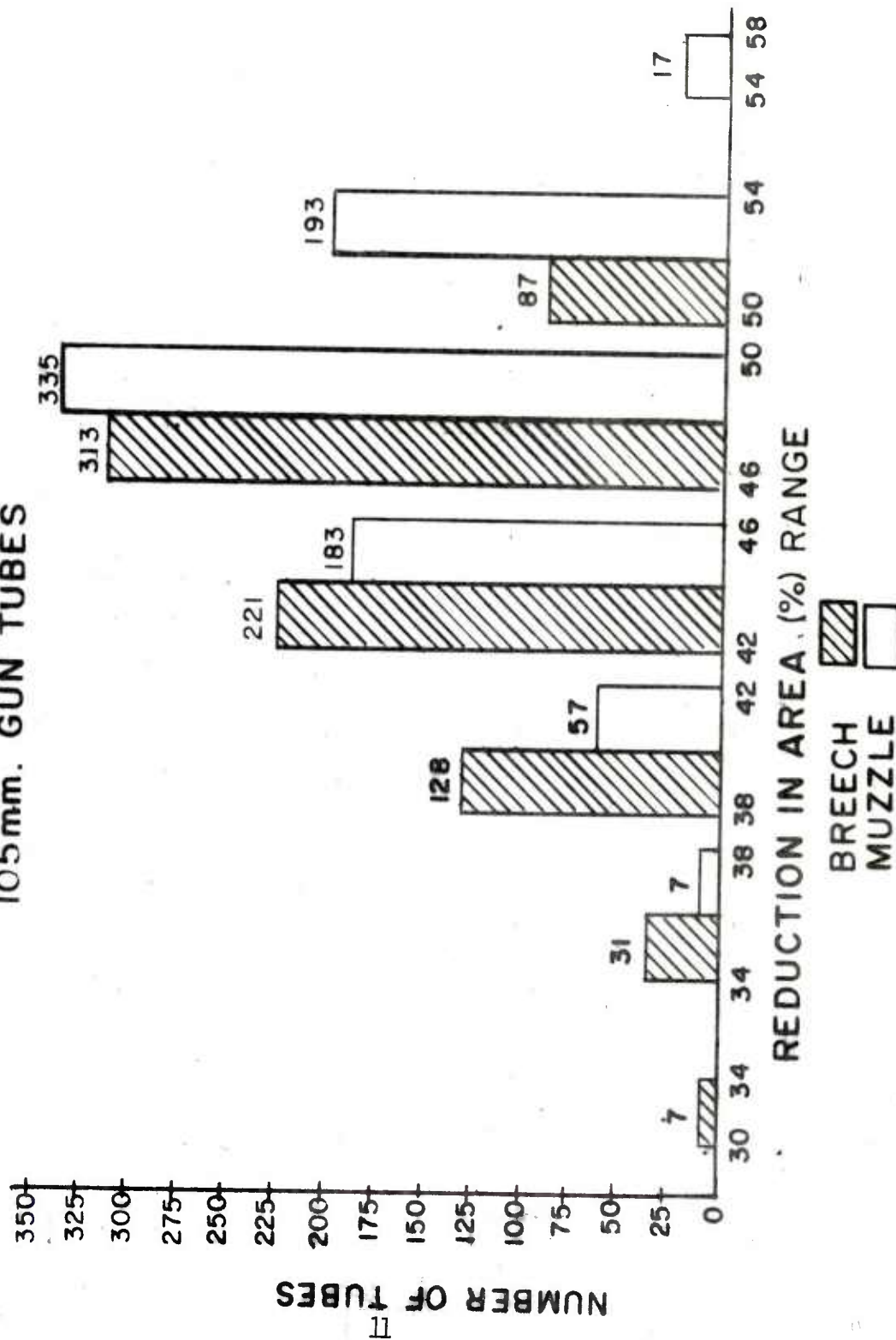
GRAPH III MECHANICAL PROPERTIES VENDOR A (1970-1973) 105mm. GUN TUBES



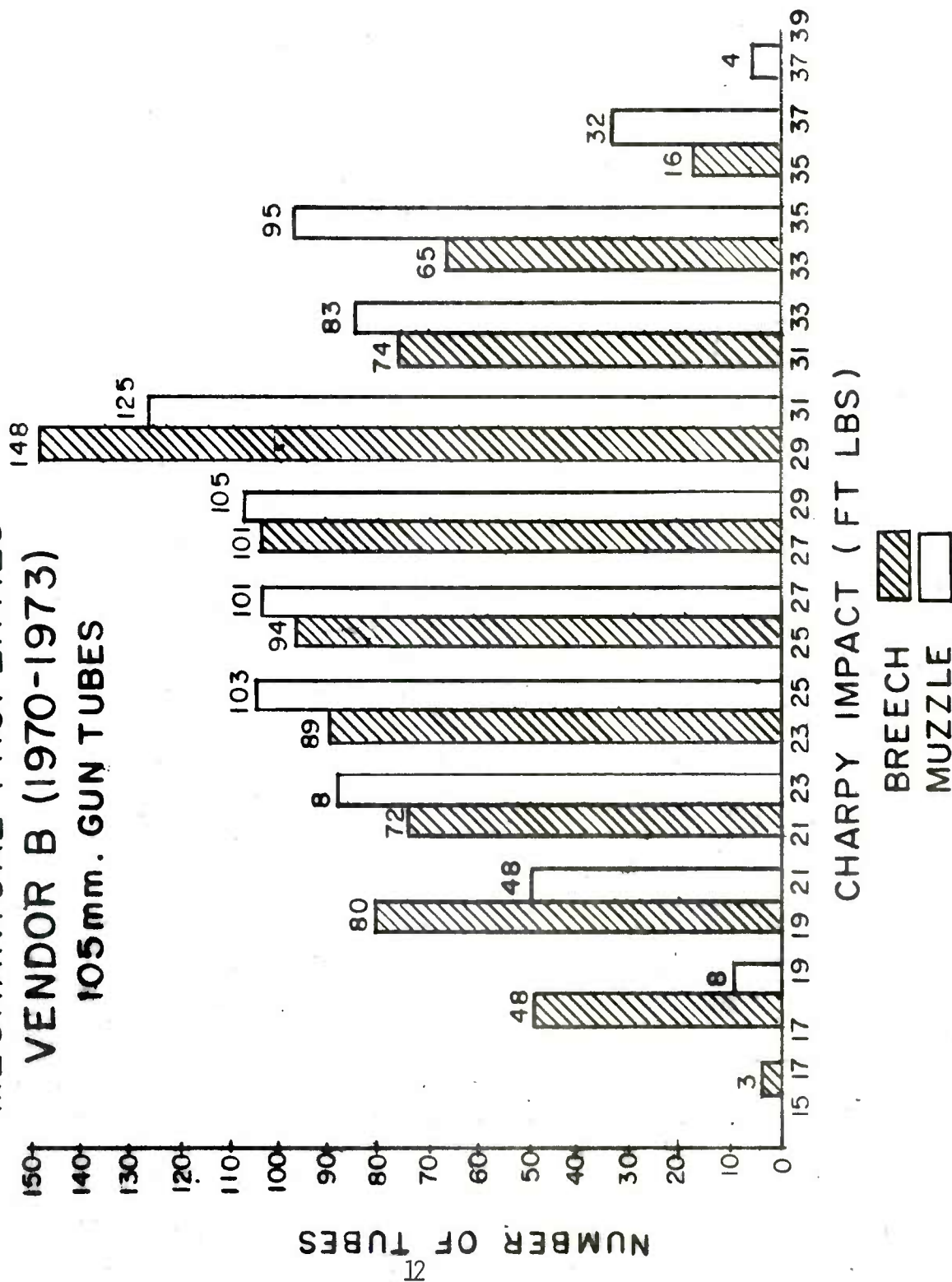
GRAPH IV MECHANICAL PROPERTIES VENDOR B (1970-1973)



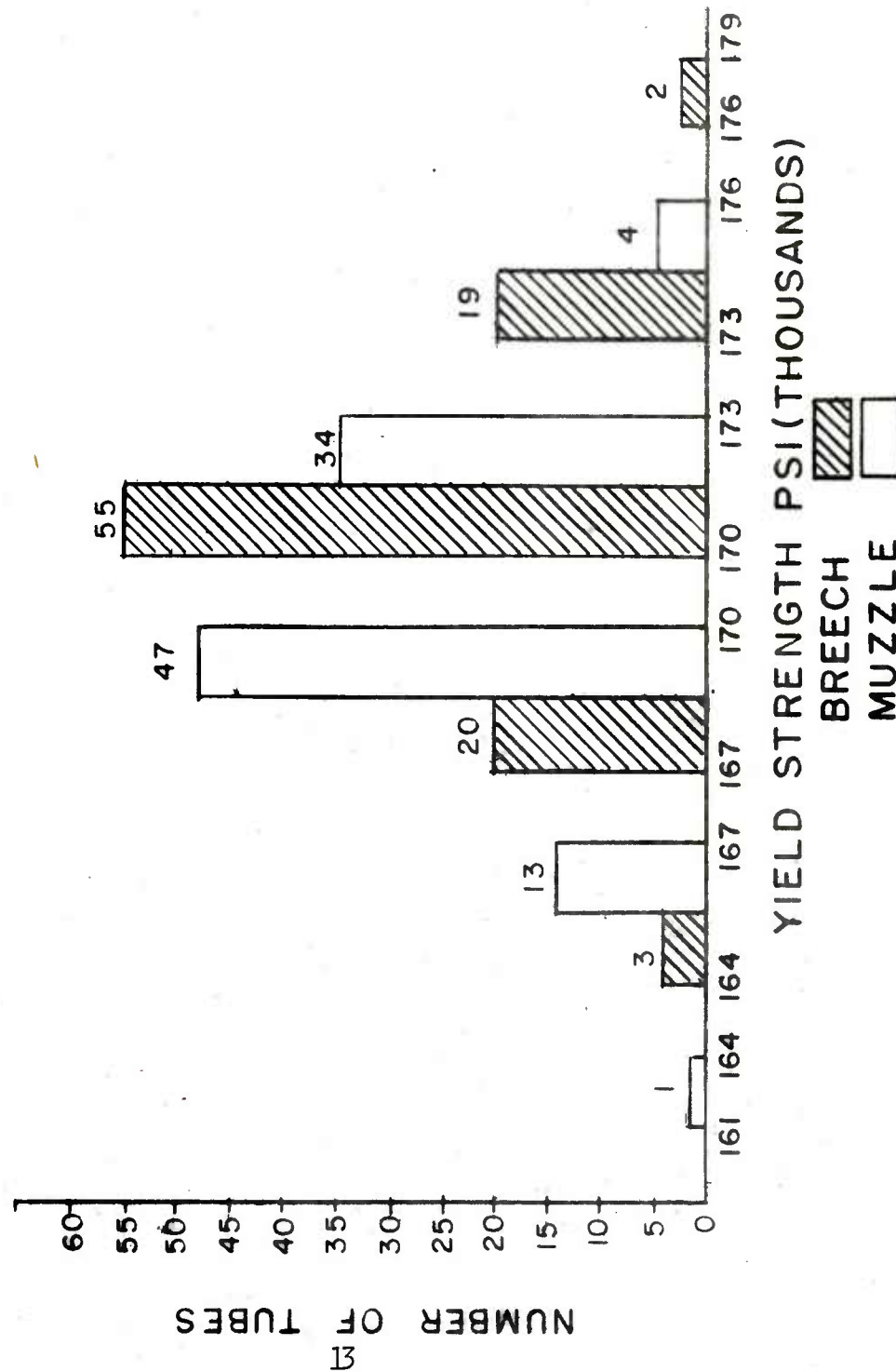
GRAPH V
MECHANICAL PROPERTIES
VENDOR B (1970-1973)
105mm. GUN TUBES



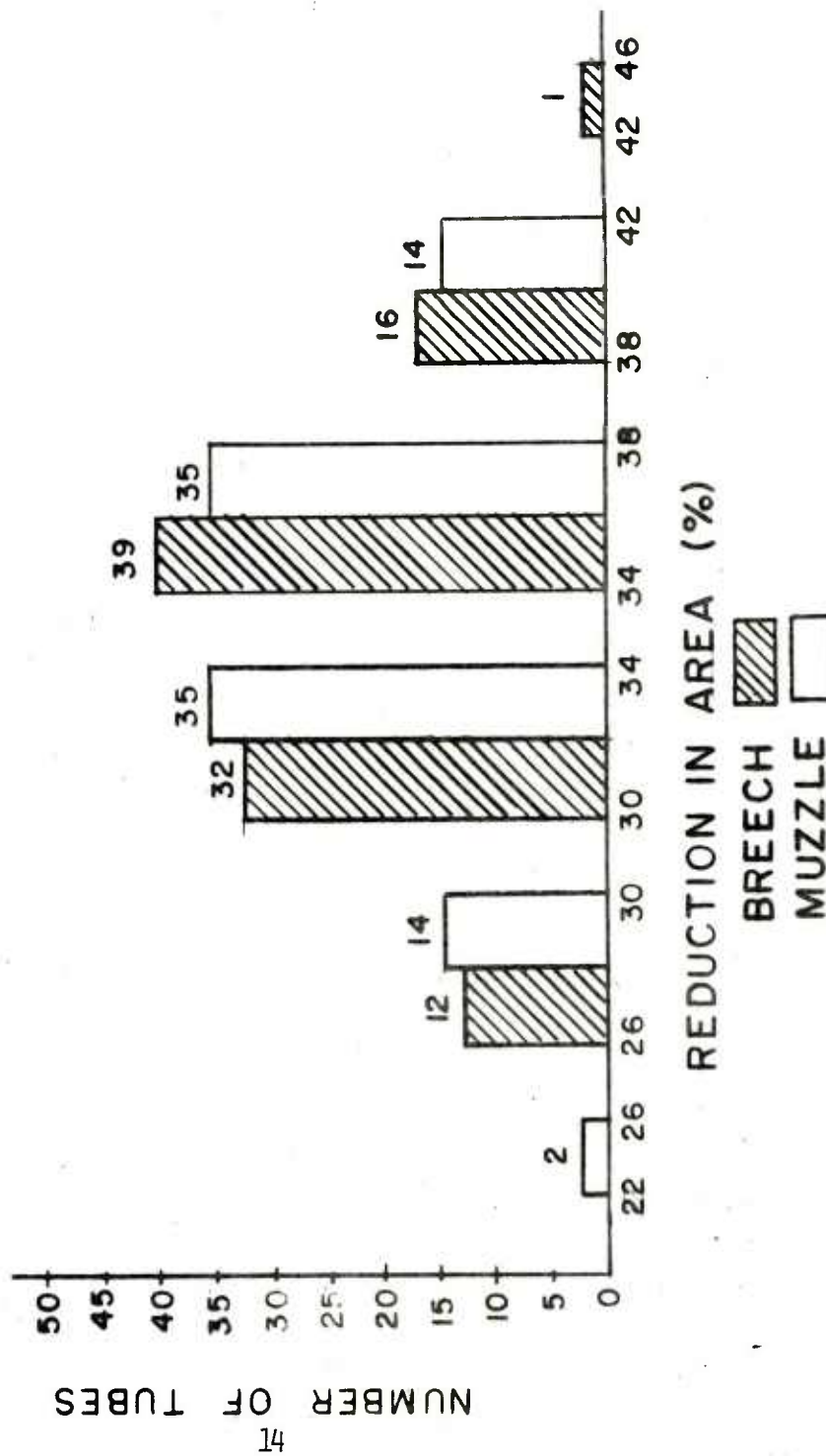
GRAPH VI
MECHANICAL PROPERTIES
VENDOR B (1970-1973)
105mm. GUN TUBES



GRAPH VII
MECHANICAL PROPERTIES
VENDOR A (1977)
105 mm. GUN TUBES

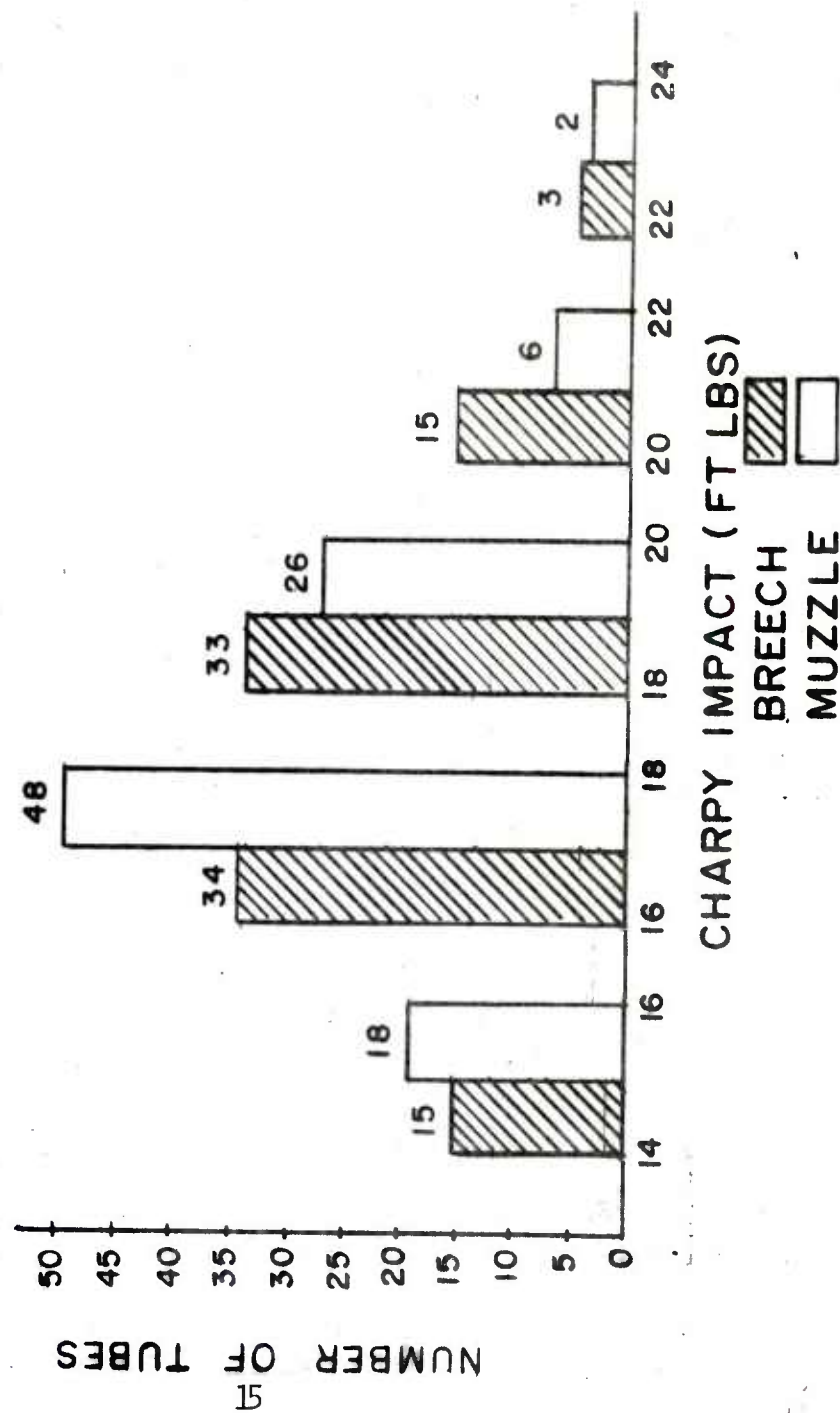


GRAPH VIII
MECHANICAL PROPERTIES
VENDOR A (1977)
105mm. GUN TUBES

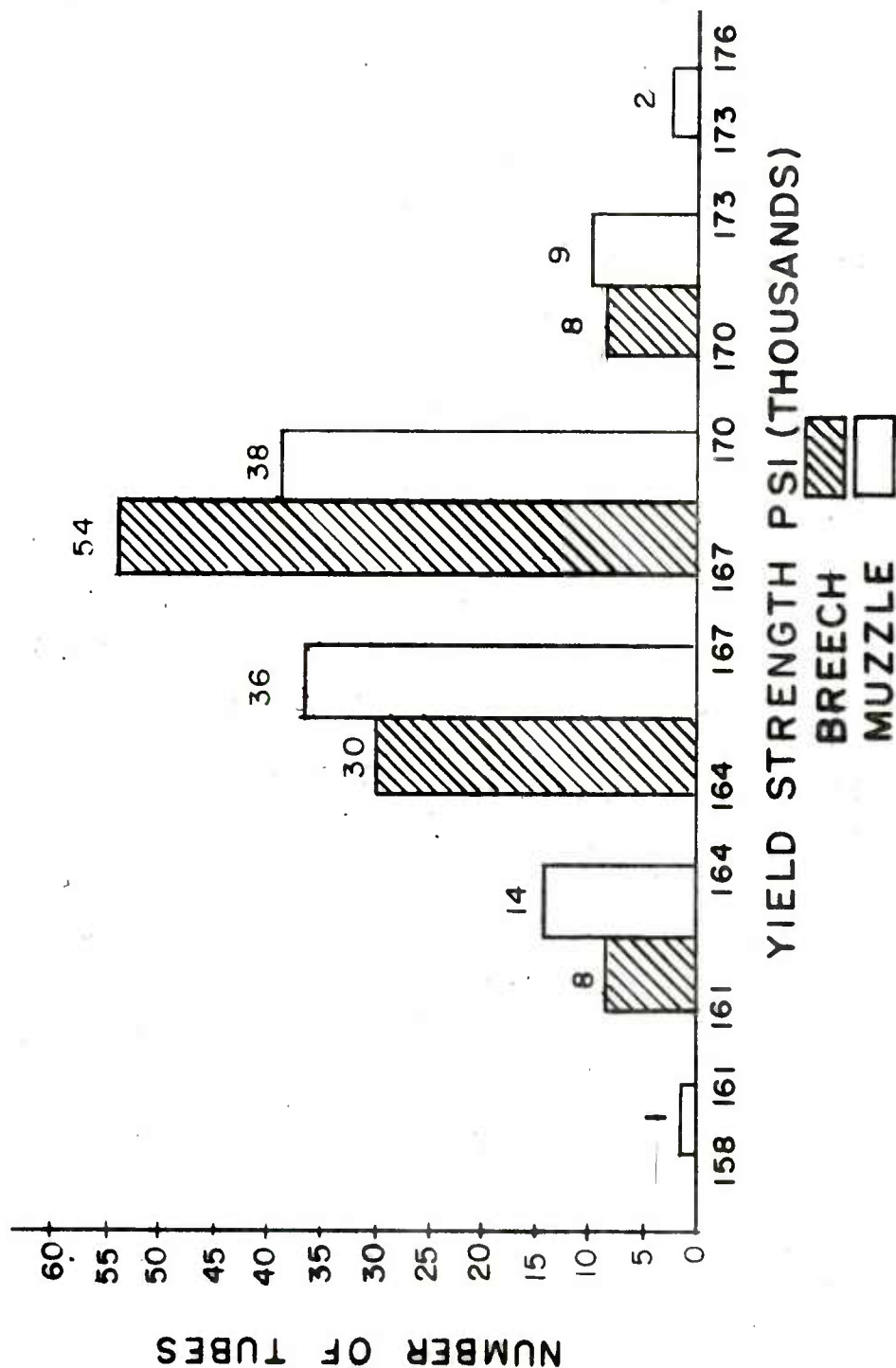


GRAPH IX MECHANICAL PROPERTIES VENDOR A (1977)

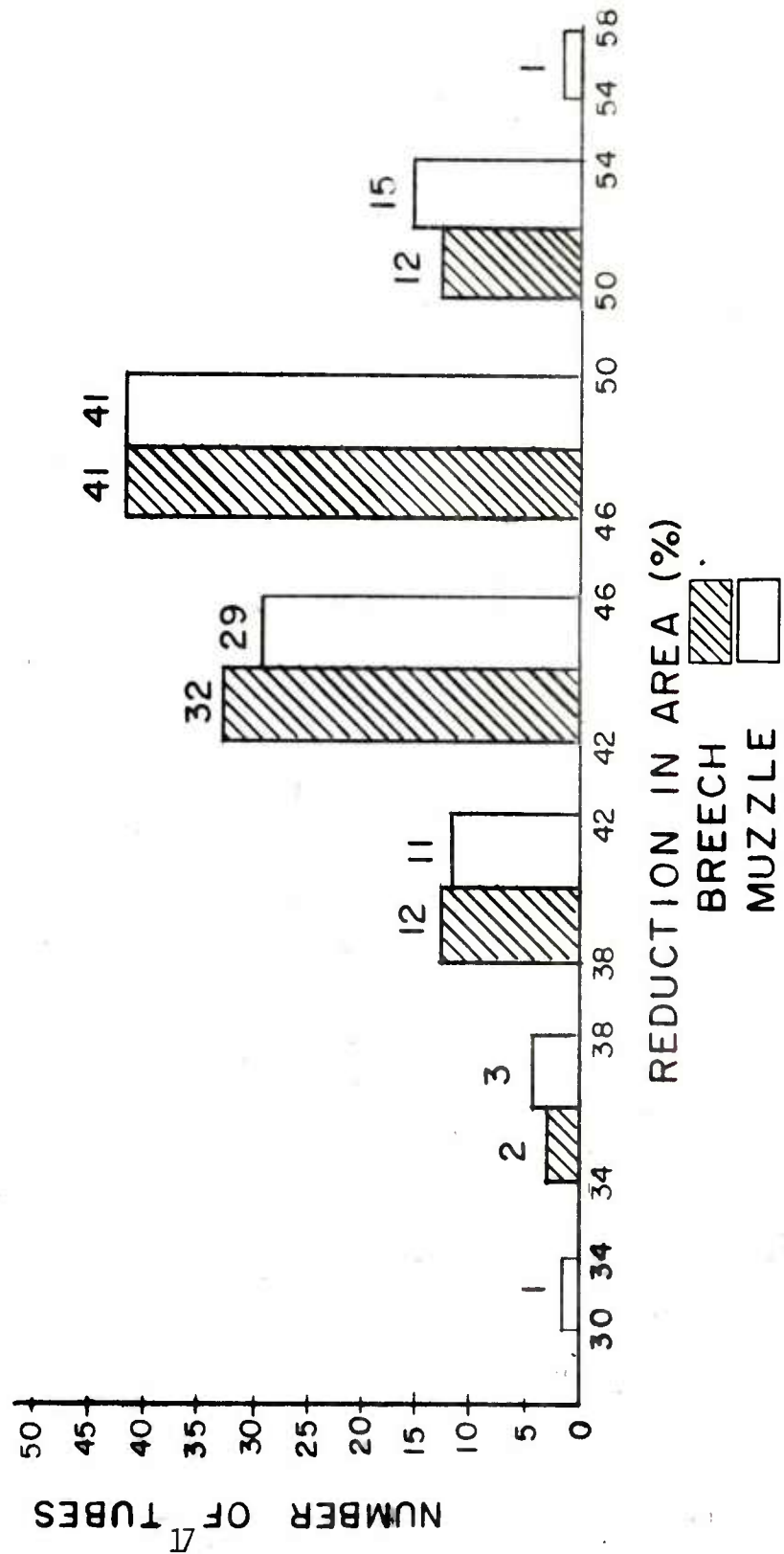
105 mm. GUN TUBES



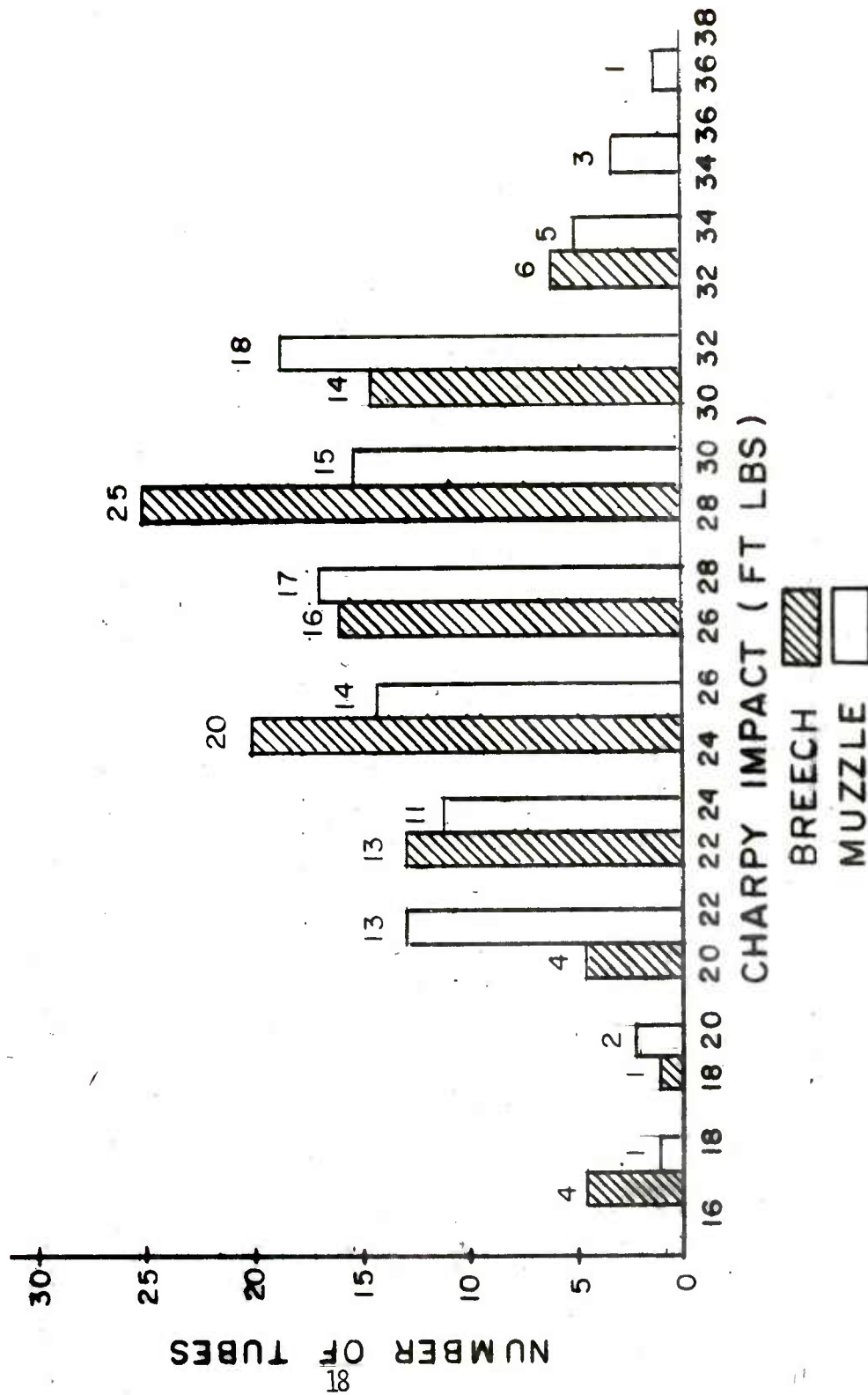
GRAPH X MECHANICAL PROPERTIES VENDOR B (1977) 105mm. GUNTUBES



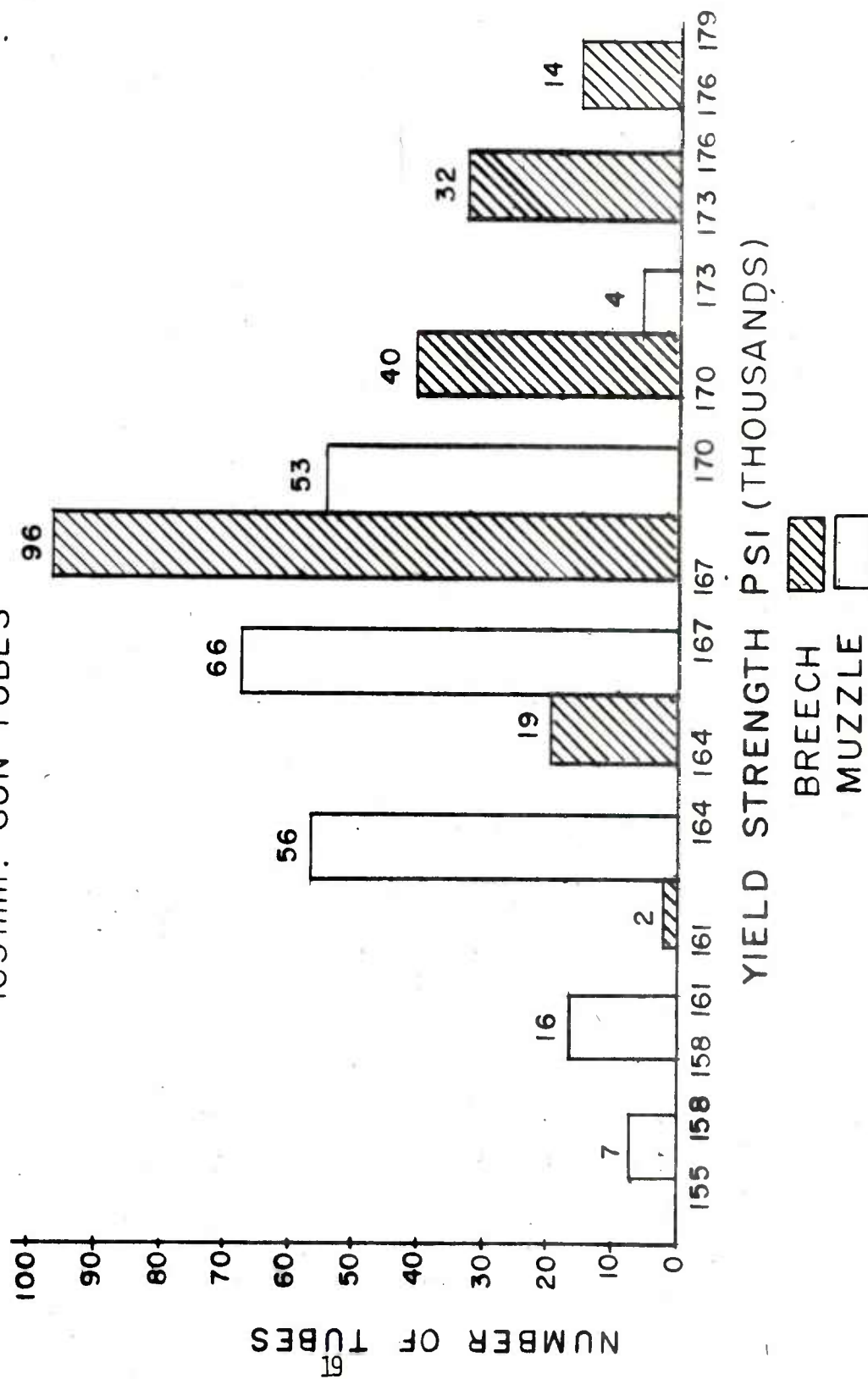
GRAPH **VI**
 MECHANICAL PROPERTIES
 VENDOR B (1977)
 105 mm. GUN TUBES



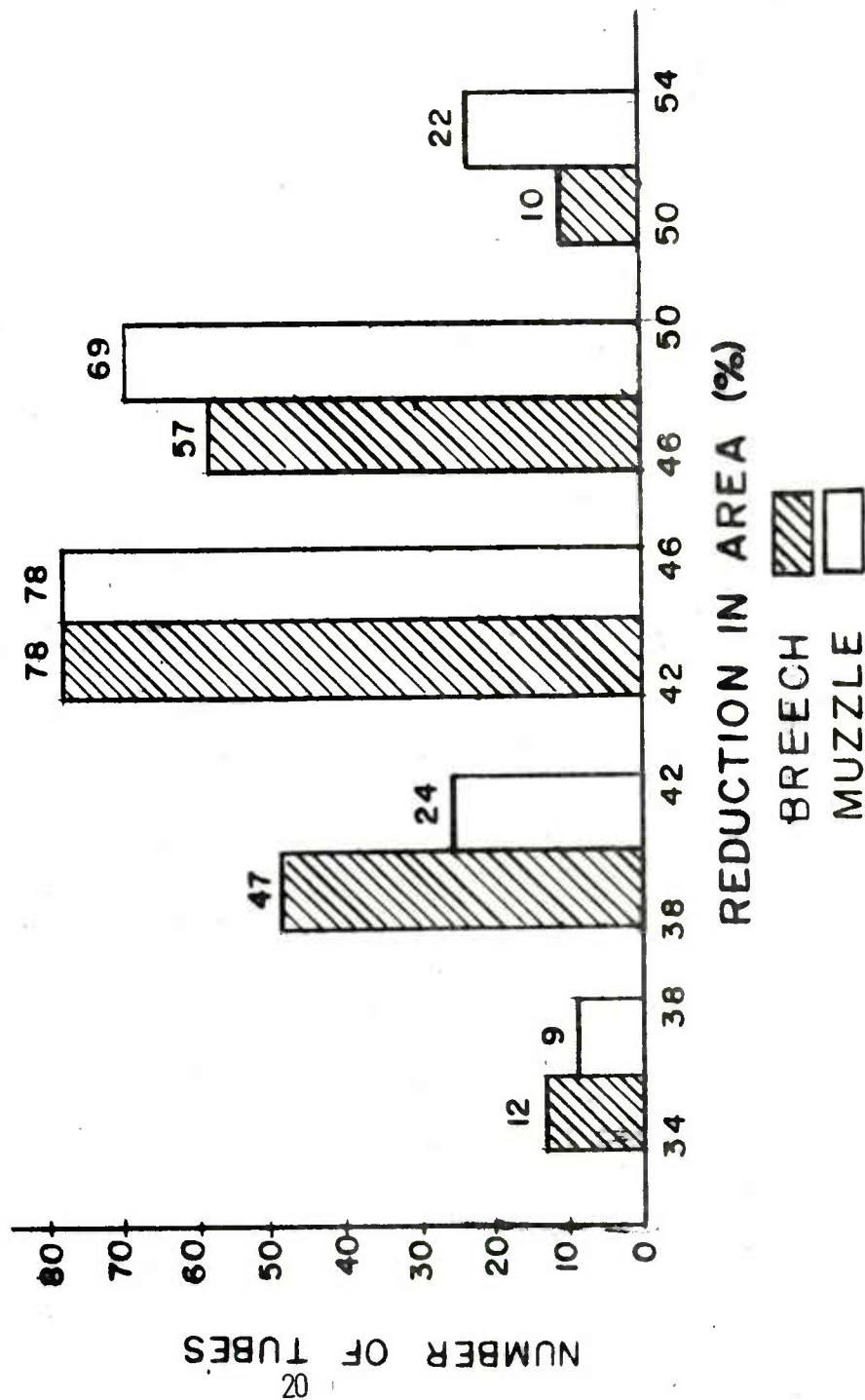
GRAPH XII
MECHANICAL PROPERTIES
VENDOR B (1977)
105mm. GUN TUBES



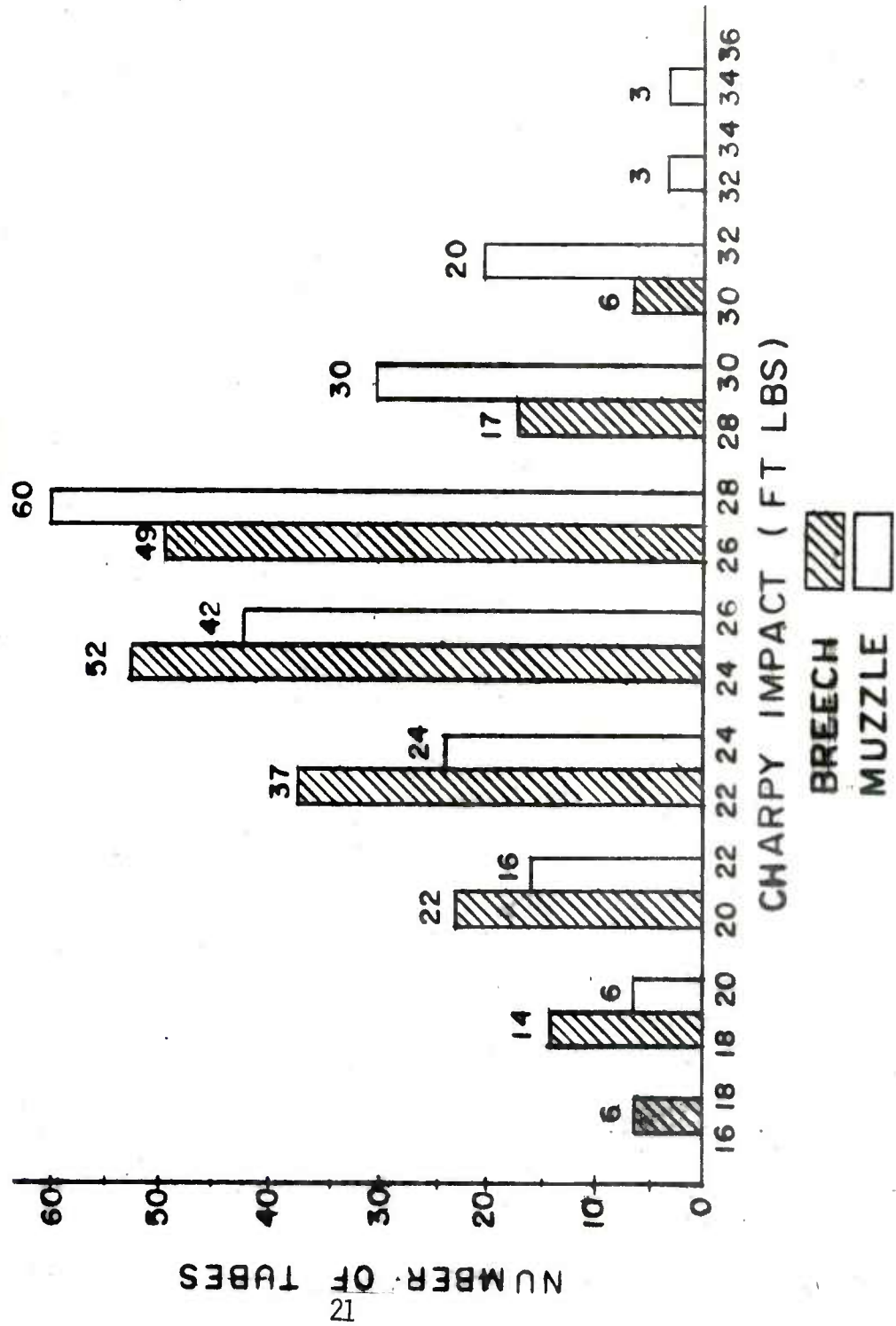
GRAPH XIII
MECHANICAL PROPERTIES
ROTARY FORGE (1977)
105 mm. GUN TUBES



GRAPH XIV
MECHANICAL PROPERTIES
ROTARY FORGE (1977)
105mm. GUN TUBES



GRAPH XV
MECHANICAL PROPERTIES
ROTARY FORGE (1977)
105mm GUN TUBES



TECHNICAL REPORT INTERNAL DISTRIBUTION LIST

	<u>NO. OF COPIES</u>
COMMANDER	1
CHIEF, DEVELOPMENT ENGINEERING BRANCH	1
ATTN: DRDAR-ICB-DA	1
-DM	1
-DP	1
-DR	1
-DS	1
-DC	1
CHIEF, ENGINEERING SUPPORT BRANCH	1
ATTN: DRDAR-ICB-SE	1
-SA	1
CHIEF, RESEARCH BRANCH	2
ATTN: DRDAR-ICB-RA	1
-RC	1
-RM	1
-RP	1
CHIEF, LWC MORTAR SYS. OFC.	1
ATTN: DRDAR-ICB-M	1
CHIEF, IMP. 81MM MORTAR OFC.	1
ATTN: DRDAR-ICB-I	1
TECHNICAL LIBRARY	5
ATTN: DRDAR-ICB-TL	
TECHNICAL PUBLICATIONS & EDITING UNIT	2
ATTN: DRDAR-ICB-TL	
DIRECTOR, OPERATIONS DIRECTORATE	1
DIRECTOR, PROCUREMENT DIRECTORATE	1
DIRECTOR, PRODUCE ASSURANCE DIRECTORATE	1

NOTE: PLEASE NOTIFY ASSOC. DIRECTOR, BENET WEAPONS LABORATORY, ATTN:
DRDAR-ICB-TL, OF ANY REQUIRED CHANGES.

TECHNICAL REPORT EXTERNAL DISTRIBUTION LIST

	<u>NO. OF COPIES</u>		<u>NO. OF COPIES</u>
ASST SEC OF THE ARMY RESEARCH & DEVELOPMENT ATTN: DEP FOR SCI & TECH THE PENTAGON WASHINGTON, D.C. 20315	1	COMMANDER US ARMY TANK-AUTMV R&D CMD ATTN: TECH LIB - DRDTA-UL MAT LAB - DRDTA-RK WARREN MICHIGAN 48090	1 1
COMMANDER US ARMY MAT DEV & READ. CMD ATTN: DRCDE 5001 EISENHOWER AVE ALEXANDRIA, VA 22333	1	COMMANDER US MILITARY ACADEMY ATTN: CHMN, MECH ENGR DEPT WEST POINT, NY 10996	1
COMMANDER US ARMY ARRADCOM ATTN: DRDAR-LC	1	COMMANDER REDSTONE ARSENAL ATTN: DRSMT-RB	2
-ICA (PLASTICS TECH EVAL CEN)	1	-RRS	1
-LCE	1	-RSM	1
-LCM	1	ALABAMA 35809	
-ICS	1	COMMANDER ROCK ISLAND ARSENAL	
-LCW	1	ATTN: SARRI-ENM (MAT SCI DIV)	1
-TSS(STINFO)	2	ROCK ISLAND, IL 61202	
DOVER, NJ 07801		COMMANDER HQ, US ARMY AVN SCH ATTN: OFC OF THE LIBRARIAN	1
COMMANDER US ARMY ARRCOM ATTN: DRSAR-LEP-L	1	FT RUCKER, ALABAMA 36362	
ROCK ISLAND ARSENAL ROCK ISLAND, IL 61299		COMMANDER US ARMY FGN SCIENCE & TECH CEN ATTN: DRXST-SD	1
DIRECTOR US Army Ballistic Research Laboratory ATTN: DRDAR-TSB-S (STINFO)	1	220 7TH STREET, N.E. CHARLOTTESVILLE, VA 22901	
ABERDEEN PROVING GROUND, MD 21005		COMMANDER US ARMY MATERIALS & MECHANICS RESEARCH CENTER	
COMMANDER US ARMY ELECTRONICS CMD ATTN: TECH LIB	1	ATTN: TECH LIB - DRXMR-PL	2
FT MONMOUTH, NJ 07703		WATERTOWN, MASS 02172	
COMMANDER US ARMY MOBILITY EQUIP R&D CMD ATTN: TECH LIB	1		
FT BELVOIR, VA 22060			

NOTE: PLEASE NOTIFY COMMANDER, ARRADCOM, ATTN: BENET WEAPONS LABORATORY, DRDAR-LCB-TL, WATERVLIET ARSENAL, WATERVLIET, N.Y. 12189, OF ANY REQUIRED CHANGES.

TECHNICAL REPORT EXTERNAL DISTRIBUTION LIST (CONT)

	NO. OF COPIES		NO. OF COPIES
COMMANDER US ARMY RESEARCH OFFICE P.O. BOX 12211 RESEARCH TRIANGLE PARK, NC 27709	1	COMMANDER DEFENSE TECHNICAL INFO CENTER ATTN: DTIA-TCA CAMERON STATION ALEXANDRIA, VA 22314	12
COMMANDER US ARMY HARRY DIAMOND LAB ATTN: TECH LIB 2800 POWDER MILL ROAD ADELPHIA, MD 20783	1	METALS & CERAMICS INFO CEN BATTELLE COLUMBUS LAB 505 KING AVE COLUMBUS, OHIO 43201	1
DIRECTOR US ARMY INDUSTRIAL BASE ENG ACT ATTN: DRXPE-MT ROCK ISLAND, IL 61201	1	MECHANICAL PROPERTIES DATA CTR BATTELLE COLUMBUS LAB 505 KING AVE COLUMBUS, OHIO 43201	1
CHIEF, MATERIALS BRANCH US ARMY R&S GROUP, EUR BOX 65, FPO N.Y. 09510	1	MATERIEL SYSTEMS ANALYSIS ACTV ATTN: DRXSY-MP ABERDEEN PROVING GROUND MARYLAND 21005	1
COMMANDER NAVAL SURFACE WEAPONS CEN ATTN: CHIEF, MAT SCIENCE DIV DAHLGREN, VA 22448	1		
DIRECTOR US NAVAL RESEARCH LAB ATTN: DIR, MECH DIV CODE 26-27 (DOC LIB) WASHINGTON, D. C. 20375	1 1		
NASA SCIENTIFIC & TECH INFO FAC P. O. BOX 8757, ATTN: ACQ BR BALTIMORE/WASHINGTON INTL AIRPORT MARYLAND 21240	1		

NOTE: PLEASE NOTIFY COMMANDER, ARRADCOM, ATTN: BENET WEAPONS LABORATORY, DRDAR-ICB-TL, WATERVLIET ARSENAL, WATERVLIET, N.Y. 12189, OF ANY REQUIRED CHANGES.